NOTES ON SOME SPECIES OF COLEOSPORIUM—I

George G. Hedgcock and N. Rex Hunt

(With Plates 20 and 21)

In a series of two papers it is proposed to give in brief detail hitherto unpublished data including the results of many sets of inoculations with the aecial, uredinial, and telial stages of a number of species of *Coleosporium*. Many negative results are given because of a theory that has been advanced, at least privately by some investigators, that in the eastern United States we probably have only two or three species of *Coleosporium*. That there are species of pine which act as natural bridging hosts which, if infected by a given species of *Coleosporium* from a certain host plant, may bear aecia whose aeciospores are capable of infecting other host plants and producing a second species of *Coleosporium*. This theory would ascribe to a species of pine the power to change the nature of a rust to such an extent that it is able to infect host plants which the urediniospores of the rust may not be able to infect. Negative results have at least some value in proving or disproving a theory, that value being determined largely by the number of cases given, and the care with which the results are obtained. None of the species of pine reported in this paper appear to be bridging hosts, in the light of the results obtained from our experiments.

Coleosporium helianthi and Coleosporium inconspicuum

The forms of *Coleosporium* occurring on species of *Coreopsis, Helianthus, Verbesina* and *Viguiera* in North America were originally assigned by Prof. J. C. Arthur to *Coleosporium helianthi* (Schw.) Arthur in 1907.[1] *Peridermium inconspicuum* Long was discovered and named by Dr. W. H. Long in 1912.[2] The proof

[1] Arthur, J. C. North American Flora, Uredinales, Coleosporiaceae. 7: 93. 1907.

[2] Long, W. H. Two New Species of Rusts. Mycologia 4: 283, 284. 1912.

of the connection of this aecial form with the *Coleosporium* on species of *Coreopsis* in 1913[3] led to the separation of *Coleosporium inconspicuum* (Long) Hedgc. & Long from *Coleosporium helianthi.* The discovery of the aecial form of *Coleosporium helianthi* by the senior writer in 1914, and the publication of the proof of its relation to the *Coleosporium* on species of *Helianthus* in 1917,[4, 5] leaves in the eastern United States the forms of *Coleosporium* on *Verbesina* and *Viguiera* without proven aecial forms.

INOCULATIONS WITH COLEOSPORIUM HELIANTHI

The superficial resemblance of the aecia of *Coleosporium helianthi* (Pl. 20, fig. 2) to those of *Coleosporium inconspicuum* (Pl. 20, fig. 1) has necessitated extensive inoculations with the aeciospores from both forms, the results of which will now be given.[6] Fortunately several of the earlier collections of the aecia of *Coleosporium helianthi* were from localities either where species of *Coreopsis* were not present, or were not infected with *Coleosporium* if present, and several collections of *Coleosporium inconspicuum* were obtained from localities either where species of *Helianthus* were not present, or if present were not infected. This afforded an opportunity to experiment with reasonably pure natural stocks of each rust. Later these results were verified by the use of aeciospores from pedigreed aecia obtained by inoculating in separate experiments trees of *Pinus virginiana* with the telia of each species of *Coleosporium.*

From 1914 to 1921, twelve sets of inoculations were made with the aeciospores of *Coleosporium helianthi* and from 1915 to 1921, fourteen sets with those of *C. inconspicuum* in the greenhouses at Washington, D. C. As in all our inoculation experiments with aeciospores and urediniospores of species of *Coleosporium,* the

[3] Hedgcock, G. G., & Long, W. H. Notes on Cultures of Three Species of *Peridermium.* Phytopathology 3: 250, 251. August, 1913.

[4] Hedgcock, G. G., & Hunt, N. R. An Alternate Form for *Coleosporium helianthi.* Phytopathology 7: 67, 68. February, 1917.

[5] Hedgcock, G. G., & Hunt, N. R. New Species of *Peridermium.* Mycologia 9: 240, 241. July, 1917.

[6] Dr. Wm. H. Long assisted the senior writer during 1913 and 1914, and Mr. N. Rex Hunt from 1915 to 1918.

spores were either placed or allowed to fall on the moistened surfaces, especially the under one, of the leaves; the plants were then kept in moist chambers or iceless refrigerators[7] 2 to 4 days, then placed in rooms or compartments of the greenhouse separate from plants inoculated with other species of *Coleosporium*. In inoculations with sporidia, whole infected plants or the leaves of infected plants were either suspended over the pine trees or laid on a wire netting over them in a large moist chamber or an iceless refrigerator for 2 to 4 days. The iceless refrigerator is the best form of inoculating chamber that we have used, more especially in warm weather. An equal number of control plants were placed uninoculated under similar conditions, apart from the inoculated sets of plants. Plants grown from healthy cuttings or from seed in the greenhouses were used. In each experiment given in this series of papers the control plants remained healthy.

In the aecial inoculations with *Coleosporium helianthi,* aeciospores from aecia collected[8] on *Pinus virginiana* from the following localities were used separately in the experiments: Greenwood Furnace, Pa.; Washington, D. C.; Chain Bridge, Va.; Black Mountain and Marion, N. C.; Greenville, S. C.; and Rome, Ga. Plants as follows were inoculated: 1 *Aster cordifolius,*[9] 1 *A. laevis,* 1 *A. undulatus,* 9 *Coreopsis major,* 10 *C. verticillata,* 1 *C. tripteris,* 1 *Chrysopsis mariana,* 16 *Helianthus decapetalus,* 6 *H. divaricatus,* 2 *H. dowellianus,* 1 *H. giganteus,* 2 *H. glaucus,* 16 *H. hirsutus,* 3 *H. microcephalus,* 2 *H. radula,* 1 *Laciniaria elegans,* 3 *Parthenium integrifolium,* 1 *Rudbeckia laciniata,* 2 *Silphium asteriscus,* 2 *S. integrifolium,* 1 *S. perfoliatum,* 1 *S. trifoliatum,*

[7] Hunt, N. Rex. The "Iceless Refrigerator" as an Inoculation Chamber. Phytopathology 9: 211–212. May, 1919.

[8] Unless otherwise credited all collections used in inoculations and noted in this series of papers were made by the senior writer.

[9] Unless the authority is designated, the names used for species of plants from the southeastern United States are those used by Small, J. H., Flora of the Southeastern United States, 1913. For those from the northeastern United States, Britton, N. L., & Brown, A., Illustrated Flora of the Northeastern United States, etc., 1898. For those from the Rocky Mountain region, Rydberg, P. A., Flora of Colorado. For those from the northwestern United States, Piper, C. V., Flora of Washington, Contributions from the National Herbarium, Vol. XI, 1906.

1 *Solidago canadensis,* 2 *Verbesina virginica* and 1 *Vernonia noveboracensis.* Of these plants, only those of species of *Helianthus* became infected, bearing mature uredinia in 12 to 15 days and mature telia in 6 weeks to 2 months. The number of plants infected of each species was as follows: 5 *H. decapetalus,* 3 *H. divaricatus,* 1 *H. giganteus,* 2 *H. glaucus,* 13 *H. hirsutus,* 1 *H. microcephalus* and 2 *H. radula.* On the last-named species the rust is now reported for the first time. Of the 20 plants of species of *Coreopsis* inoculated, none were infected.

Inoculations were made with the urediniospores of *Coleosporium helianthi* from *Helianthus hirsutus* obtained from previous inoculations June 10, 1919, on the following plants: 2 *H. hirsutus,* 2 *H. radula,* 2 *Coreopsis major* and 4 *C. verticillata.* All the plants of *Helianthus* became infected, bearing mature uredinia June 26 and telia July 20. All plants of *Coreopsis* remained free from infection.

Pine trees were inoculated September 29, 1920, with the sporidia from the telia of *Coleosporium helianthi* on *Helianthus decapetalus* collected the previous day near Chain Bridge, Va. The following trees were inoculated: 1 *P. caribaea,* 1 *P. edulis* Engelm., 1 *P. glabra,* 2 *P. radiata* Don. and 8 *P. virginiana.* Seven trees of the last-named species were infected, many mature pycnia appearing on the needles by March 21, 1921, and abundant mature aecia by April 20. The other trees remained uninfected.

Aeciospores of *Coleosporium helianthi* from the preceding experiment were inoculated April 20, 1921, on the following plants: 1 *Coreopsis major,* 2 *C. verticillata,* 1 *Helianthus divaricatus* and 2 *H. hirsutus.* Only the three plants of *Helianthus* were infected with the *Coleosporium,* producing both the uredinial and telial stages.

INOCULATIONS WITH COLEOSPORIUM INCONSPICUUM

In the aecial inoculations with *Coleosporium inconspicuum,* aeciospores from aecia collected on *Pinus virginiana* from the following localities were used separately in the experiments: Takoma Park, Md.; Washington, D. C.; Roanoke, Va.; Asheville, Black Mountain and Hot Springs, N. C. Plants as follows were inocu-

lated: 1 *Chrysopsis mariana,* 1 *Coreopsis lanceolata,* 16 *C. major,* 1 *C. tripteris,* 26 *C. verticillata,* 1 *Elephantopus carolinianus,* 10 *Helianthus decapetalus,* 1 *H. divaricatus,* 2 *H. dowellianus,* 1 *H. glaucus,* 10 *H. hirsutus,* 4 *H. microcephalus,* 1 *H. occidentalis,* 1 *H. tuberosus,* 1 *Laciniaria elegans,* 2 *Silphium integrifolium,* 4 *Verbesina virginica,* 2 *Vernonia blodgettii,* 3 *V. flaccidifolia,* 1 *V. glauca,* 2 *V. oligantha* and 2 *V. noveboracensis.* Of these plants, only those of species of *Coreopsis* became infected, many of them abundantly, bearing mature uredinia in 13 to 16 days, and mature telia in about 2 months. The number of plants of each species infected was as follows: 1 *C. lanceolata,* 7 *C. major,* 20 *C. verticillata* and 1 *C. tripteris.*

Aeciospores of *Coleosporium inconspicuum* from aecia on *Pinus echinata* collected near Mt. Airy, N. C., were used March 22, 1919, to inoculate plants as follows: 2 *Coreopsis major,* 1 *C. verticillata* and 1 *Helianthus hirsutus,* and on the same date a duplicate set of plants was inoculated with aeciospores from a collection of aecia on *Pinus palustris* made near Styx, S. C., May 11. In each of these two experiments, only the plants of *C. verticillata* became infected with the *Coleosporium,* proving it to be *C. inconspicuum* in each case.

Pine trees were inoculated September 29, 1920, with the sporidia from the telia of *Coleosporium inconspicuum* on *Coreopsis verticillata,* collected the preceding day in Virginia, near Washington, D. C. The following trees were inoculated: 1 *Pinus glabra,* 4 *P. virginiana.* All the trees of the latter species were infected, bearing mature pycnia on the needles by March 2, 1921, and mature aecia by April 20.

Aeciospores of *Coleosporium inconspicuum* from the preceding experiment were inoculated April 20, 1921, on the following plants: 1 *Coreopsis major,* 6 *C. verticillata* and 2 *Helianthus hirsutus.* The one plant of *C. major* and 4 of *C. verticillata* were infected with the *Coleosporium,* producing both the uredinial and telial stages.

All our inoculations fail to furnish the slightest proof that *Coleosporium helianthi* and *C. inconspicuum* are identical physiologically, but on the contrary indicate that they are distinct species.

The aecial forms of the two species do not differ widely in morphology, as is shown by the following table:

TABLE OF COMPARISON

Coleosporium helianthi	*Coleosporium inconspicuum*
Pycnia solitary or few, clustered, deep chrome[10] to raw umber. When fresh, 0.38 mm. wide by 0.5 mm. long.[11]	*Pycnia* few to many, in extended rows, yellow ochre to Dresden brown when fresh, 0.28 mm. wide by 0.64 mm. long.
Aecia solitary or few, aggregated, linguaform to flattened rhomboidal. 0.9 mm. high by 1 mm. long (plate 20, fig. 2).	*Aecia* few to many, aggregated or in short rows, tubular to linguaform, 0.9 mm. high by 0.6 mm. long (plate 20, fig. 1).
Peridial cells 17 by 36 μ, walls 5 μ thick.	*Peridial cells* 20 by 38 μ, walls 4 μ thick.
Aeciospores 16 by 27 μ, walls 2.6 μ thick.	*Aeciospores* 15 by 25 μ, walls 2.4 μ thick.

The pycnia of *Coleosporium inconspicuum* are slightly darker in color, and the aecia are more nearly tubular (Plate 20, fig. 1) than those of *Coleosporium helianthi,* which are more commonly flattened (Plate 20, fig. 2).

THE COLEOSPORIUM ON VERBESINA

The *Coleosporium* occurring on *Verbesina* has been assigned by Prof. Arthur to *Coleosporium helianthi.* In the experiments already mentioned with aeciospores of both *C. helianthi* and *C. inconspicuum* all plants of *Verbesina* failed of infection. The following inoculations were made with the *Coleosporium* from *Verbesina* obtained in Florida:

March 12, 1914, urediniospores from a collection made by Dr. Long at New Smyrna, March 9, were used to inoculate the following plants without infection: 1 *Elephantopus carolinianus,* 2 *E. tomentosus,* 1 *Solidago bicolor,* 2 *S. juncea* and 1 *Vernonia glauca.*

March 11, 1915, urediniospores from a collection by the senior writer in the same locality, March 4, were used to inoculate successfully 3 plants of *Verbesina virginica,* which bore uredinia

[10] Colors used are those of Ridgway, R. Color standards and nomenclature. Washington, D. C. 1912.

[11] Measurements are based on an average of 60, 10 each for six different collections.

March 30 and telia May 25. April 28, 18 plants of *Verbesina* were successfully inoculated with urediniospores from the previous culture, bearing mature uredinia in 14 to 18 days and telia in about 2 months.

In 1919, urediniospores were again obtained from a collection by Dr. Long at East Palm Beach, and the following plants were inoculated: 2 *Coreopsis verticillata,* 4 *C. major,* 2 *Elephantopus carolinianus,* 4 *H. decapetalus,* 6 *H. hirsutus,* 3 *H. radula,* 2 *Silphium asteriscum,* 2 *S. integrifolium,* 13 *Verbesina virginica* and 2 *Vernonia flaccidifolia.* Only the plants of *Verbesina* were infected, bearing mature uredinia in 14 to 17 days and telia in about 2 months.

Since the urediniospores of this *Coleosporium* from *Verbesina* do not infect plants of species of *Coreopsis, Elephantopus, Helianthus, Silphium, Solidago* and *Vernonia,* it appears it does not belong to any of the species of *Coleosporium* attacking these plants, viz., *C. inconspicuum, C. helianthi, C. terebinthinaceae, C. solidaginis* and *C. carneum,* and it is predicted that it has a distinct aecial form not yet collected or known.

DISTRIBUTION OF THE SPECIES

Coleosporium helianthi, according to our records, has been collected in the United States as follows:

O and I on *Pinus:*

P banksiana: Michigan.

P. echinata: Georgia.

P. virginiana: Maryland, Pennsylvania, North Carolina, South Carolina. Tennessee, Virginia and West Virginia.

II and III on *Helianthus:*

H. australis: North Carolina.

H. decapetalus: Indiana, Maryland, New York, North Carolina, South Carolina, Pennsylvania, Tennessee and Virginia.

H. divaricatus: District of Columbia, Georgia, North Carolina, Pennsylvania, Tennessee and Virginia.

H. doroconoides: Ohio and Minnesota.

H. eggertii: Tennessee.

H. giganteus: Alabama, Mississippi, New York, Pennsylvania and West Virginia.

H. glaucus: Georgia and Tennessee.

H. grosseserratus: North Carolina and West Virginia.

H. microcephalus: Alabama, Georgia, North Carolina, South Carolina, Tennessee and Virginia.

H. occidentalis: Louisiana.

H. saxicola Small: Georgia.

H. strumosus: Alabama.

H. tuberosus: Alabama, South Carolina and Virginia.

Coleosporium helianthi has been successfully inoculated upon the following species: *Pinus virginiana, Helianthus decapetalus, H. divaricatus, H. glaucus, H. microcephalus* and *H. radula.*

Coleosporium inconspicuum, according to our records, has been collected in the United States as follows:

O and I on *Pinus:*

P. echinata: Georgia and North Carolina.

P. palustris: South Carolina.

P. virginiana: District of Columbia, Georgia, Maryland, North Carolina and Virginia.

II and III on *Coreopsis:*

C. delphinifolia: Tennessee.

C. lanceolata: North Carolina and Tennessee.

C. major: Georgia, North Carolina, South Carolina and Tennessee.

C. major oemleri: Georgia, North Carolina, Tennessee and Virginia.

C. major rigida: Georgia, North Carolina and Tennessee.

C. tripteris: Georgia and Tennessee.

C. verticillata: District of Columbia, Maryland, North Carolina and Virginia.

Coleosporium inconspicuum has been successfully inoculated upon the following species: *Pinus virginiana, Coreopsis lanceolata, C. major, C. verticillata* and *C. tripteris.*

From the foregoing data, it will readily be seen that *Coleosporium helianthi* has a much wider known distribution in the United States than *Coleosporium inconspicuum,* as it ranges from Minnesota and New York on the north to Louisiana and Georgia on the south, as compared with a range for *C. inconspicuum* from Maryland and Michigan south to Georgia and west to Tennessee.

COLEOSPORIUM TEREBINTHINACEAE

Coleosporium terebinthinaceae (Schw.) Arthur was first described in the uredinial stage as *Uredo terebinthinaceae* by Schweinitz[12] in 1822. It was transferred to the genus *Coleosporium* by Professor Arthur[13] in 1907. The aecial form was discovered by the senior writer in 1916, and described in 1917.[14]

[12] Schweinitz, L. D. Synopsis Fungorum Carolinae Superoris. Schrift. Naturf. Ges. Leipzig 1: 70. 1822.

[13] Arthur, J. C. North American Flora, Uredinales, *Coleosporium.* 7: 93. 1907.

[14] Hedgcock, Geo. G., & Hunt, N. Rex. New Species of *Peridermium.* Mycologia 9: 240. 1917.

In the study of *Coleosporium terebinthinaceae* the following inoculations have been made:

During May, 1916, and April, 1918, 7 sets of separate inoculations were made with aeciospores from collections made on *Pinus echinata* at Auburn, Ala.; Gainesville, Ga.; Clearwater, S. C.; and Marion, N. C. Plants of the following species were inoculated: 3 *Amsonia ciliata,* 2 *Coreopsis verticillata,* 2 *Laciniaria gramifolia,* 10 *Parthenium integrifolium,* 1 *Silphium asteriscus,* 13 *S. integrifolium* and 3 *S. trifoliatum.* The following plants were infected, some of them heavily, bearing mature uredinia in 11 to 13 days and telia in about 2 months: 1 *Silphium asteriscus,* 4 *S. integrifolium,* 3 *S. trifoliatum* and 1 *Parthenium integrifolium.*

Urediniospores obtained from *Silphium integrifolium* in one of the preceding inoculations were used June 27, 1916, to inoculate plants as follows: 2 *Silphium integrifolium,* 1 *S. trifoliatum* and 2 *Parthenium integrifolium.* One plant each of *S. integrifolium* and *S. trifoliatum* were infected heavily, bearing mature uredinia in 13 days and mature telia in about 2 months.

A number of inoculations were made with telia on several species of pine during 1915 and 1916 without infection.

Although plants of but few species have been tested by inoculation with the aeciospores of *C. terebinthinaceae,* a large number of plants of species of *Silphium* and *Parthenium* susceptible to this species of *Coleosporium* have been tested, without infection, by inoculation with the aeciospores of the following species of *Coleosporium: C. carneum* (Bosc.) Jackson, *C. elephantopodis* (Schw.) Thüm., *C. helianthi* (Schw.) Arthur, *C. inconspicuum* (Long) Hedgc. & Long, *C. ipomoeae* (Schw.) Burrill, *C. minutum* Hedgc. & Hunt, and *C. solidaginis* (Schw.) Thüm.

Coleosporium terebinthinaceae according to our records has been collected in the United States as follows:

O and I on *Pinus:*
P. echinata: Alabama, Georgia, North Carolina and South Carolina.
P. palustris: South Carolina.
P. rigida: North Carolina.
P. serotina: South Carolina.
P. taeda: Alabama and South Carolina.
II and III on *Parthenium* and *Silphium:*
P. integrifolium: Alabama, Georgia, North Carolina, Tennessee and Virginia.

S. angustatum: Alabama, Georgia and South Carolina.

S. asperrimum: Texas.

S. asteriscus: Georgia, Louisiana, North Carolina and South Carolina.

S. compositum: Alabama, Georgia, North Carolina, Tennessee and Virginia.

S. dentatum: Georgia, North Carolina and South Carolina.

S. glabrum Eggert: Georgia and Tennessee.

S. gracile: Texas.

S. integrifolium: Alabama, Arkansas, Georgia, Illinois, Indiana, Louisiana, Mississippi and Missouri.

S. laciniatum: Iowa and Kansas.

S. laevigatum: Alabama.

S. pinnatifidum: Georgia.

S. scaberrimum: Texas.

S. terebinthinaceum: Illinois, Indiana and North Carolina.

S. trifoliatum: Alabama, North Carolina and Virginia.

Coleosporium terebinthinaceae has been successfully inoculated upon *Parthenium integrifolium, Silphium asteriscus, S. integrifolium,* and *S. trifoliatum.*

The aecial stage of this *Coleosporium* is a small species, resembling somewhat *C. laciniariae* Arthur, *C. helianthi*[15] and *C. inconspicuum.*

A comparison of the morphology of *Coleosporium terebinthinaceae* with that of *C. laciniariae* follows:

TABLE OF COMPARISON

Coleosporium terebinthinaceae	*Coleosporium laciniariae.*
Pycnia solitary or few, usually in short rows, orange-rufous to mummy-brown when fresh, on olive-yellow spots, 0.2 mm. wide by 0.4 mm. long.	*Pycnia* solitary or few, usually aggregated, salmon-orange to olivaceous-black when fresh, on light-green spots, 0.4 mm. wide by 0.6 mm. long.
Aecia solitary to few, usually in short rows, linguaform to flattened rhomboidal, 1.4 mm. high by 1.1 mm. long.	*Aecia* solitary to few, usually aggregated, flattened rhomboidal, 0.4 mm. high by 1.5 mm. long.
Aeciospores 20 by 30 μ with walls 3 μ thick.	*Aeciospores* 20 by 31 μ with walls 2 μ thick.
Peridial cells 26 by 53 μ with walls 4 μ thick.	*Peridial cells* 25 by 40 μ with walls 5 μ thick.

The pycnia of *Coleosporium terebinthinaceae* are brown and those of *C. laciniariae* are black at the time when the aecia are beginning to appear. It is possible at this stage to determine most

[15] For a comparison with the aecial stages of *C. helianthi* and *C. inconspicuum,* see the "Table of Comparison" on another page of this article.

of the species of *Coleosporium* in the eastern United States from pycnial characters, where freshly collected specimens are available.

COLEOSPORIUM DELICATULUM

Coleosporium delicatulum (Arthur & Kern) Hedgc. & Long was first described in the aecial stage by Arthur and Kern[16] in 1906 as *Peridermium delicatulum.* Proof of the connection of the aecial stage on *Pinus rigida* with the uredinial stage on *Euthamia graminifolia* was obtained by Dr. Long and the senior writer[17] and published in 1913.

Inoculations with *Coleosporium delicatulum* have since been made as follows: During April and May, 1913, nine sets of inoculations were made with aeciospores from collections of aecia made on *Pinus rigida* near Takoma Park, D. C. The following plants were inoculated: 1 *Aster conspicuus,* 2 *A. cordifolius,* 3 *A. ericoides,* 1 *A. hesperius,* 1 *A. laevis geyeri,* 3 *A. lenta,* 1 *A. paniculatus,* 3 *A. undulatus,* 14 *Euthamia graminifolia,* 2 *Helianthus divaricatus,* 1 *Ribes nigrum,* 4 *Senecio aureus,* 4 *Solidago bicolor,* 2 *S. canadensis,* 2 *S. erecta,* 5 *S. juncea,* 2 *S. multiradiata* Ait., 3 *S. rugosa* and 1 *S. speciosa.* Of these plants only those of *Euthamia graminifolia* were infected, having mature uredinia in 14 to 16 days and telia in about 2 months.

During May and June, 1914, three sets of inoculations were made with aeciospores from the same source as in 1913. Plants of the following species were inoculated: 1 *A. laevis,* 3 *A. laevis geyeri,* 1 *A. undulatus,* 1 *Elephantopus tomentosus,* 18 *Euthamia graminifolia,* 1 *Helianthus occidentalis,* 2 *Solidago canadensis,* 2 *S. multiradiata,* 3 *S. rugosa* and 2 *Vernonia noveboracensis.* Of these plants only those of *Euthamia* were infected and bore uredinia and telia as in the preceding experiments.

Aeciospores from aecia collected on *Pinus palustris* by Dr. Long at Brooksville, Fla., March 27, were used April 3, 1914, to inoculate plants of the following species: 3 *Euthamia graminifolia,* 1 *Eupatorium maculatum* and 1 *Solidago rugosa.* The plants of *Euthamia* were infected and bore uredinia and telia as before.

[16] Arthur, J. C., & Kern, F. D. North American Species of *Peridermium.* Bul. Torrey Bot. Club 33: 404. 1906.

[17] Hedgcock, Geo. G., & Long, W. H. Notes on Cultures of Three Species of *Peridermium.* Phytopathology 3: 250. 1913.

April 3, 1914, aeciospores from aecia collected on *Pinus serotina* by Dr. Long at St. Augustine, Fla., March 30, were used to inoculate plants of the following species: 2 *Euthamia graminifolia* and 2 *Solidago rugosa*. Only the plants of *Euthamia* were infected and bore uredinia and telia as before.

During March and April, 1914, aeciospores from aecia collected on *Pinus taeda* by Dr. Long at Brooksville and St. Augustine, Fla., and Henry, S. C., were used to inoculate plants of the following species: 9 *Euthamia graminifolia*, 1 *Helianthus annuus*, 1 *Solidago rugosa* and 3 *S. speciosa*. Only the plants of *Euthamia* became infected and bore uredinia and telia as before.

During April, 1915, aeciospores from aecia collected on *Pinus echinata* at Florence, S. C., were used to inoculate and infect 1 plant of *Euthamia caroliniana* and 2 of *E. graminifolia*, which as a result bore uredinia and telia. Also aeciospores from aecia collected on *Pinus caribaea* at Jacksonville, Fla., were used to infect 3 plants of *Euthamia graminifolia* which bore uredinia and telia as before.

During June, 1916, aeciospores from aecia on *Pinus resinosa* collected by Dr. P. Spaulding at Sharon, Vt., were used to infect *Euthamia graminifolia*, which as a result bore uredinia and telia. Plants of *Euthamia* infected during 1914, 1915, and 1916, bore mature uredinia in 11 to 18 days and mature telia in 5 to 8 weeks.

Inoculations with the sporidia from the telia of *Coleosporium delicatulum* have been made on pine trees as follows:

September 11, 1916, the following were inoculated with sporidia from telia collected September 10 near Takoma Park, D. C.: 1 *Pinus caribaea*,[18] 2 *P. clausa*, 1 *P. contorta*, 1 *P. coulteri*, 1 *P. densiflora* Thunb., 2 *P. echinata*, 2 *P. edulis*, 3 *P. glabra*, 2 *P. mayriana* Sudw., 1 *P. monophylla*, 1 *P. montana* Mill., 1 *P. palustris*, 2 *P. rigida*, 1 *P. scopulorum*, 2 *P. serotina*, 2 *P. taeda* and 1 *P. thunbergii* Parl. Of these trees the following were infected, bearing mature pycnia in January and mature aecia in March, 1917: 1 *P. contorta*, 2 *P. echinata*, 2 *P. glabra*, 1 *P. mayriana*, 1 *P. palustris*, 2 *P. rigida*, 2 *P. serotina* and 1 *P. taeda*.

[18] In these two papers, *P. heterophylla* is considered synonymous with *P. caribaea*, and *P. murrayana* with *P. contorta*.

October 13, 1920, sporidia from telia on *Euthamia graminifolia,* collected the same day near Chain Bridge, D. C., were used to inoculate trees of the following species in pots sunk in beds outside of the greenhouses: 1 *Pinus canariensis* C. Smith, 3 *P. caribaea,* 7 *P. contorta,* 3 *P. coulteri,* 2 *P. echinata,* 1 *P. edulis,* 1 *P. glabra,* 1 *P. mayriana* and 2 *P. scopulorum.* Of these the following were infected, bearing mature pycnia in March and mature aecia late in April, 1921: 1 *P. caribaea,* 1 *P. coulteri* and 2 *P. scopulorum.*

The pycnial stage of *Coleosporium delicatulum* resembles closely that of *C. solidaginis* but the pycnial areas of the former are much brighter colored. The aecia differ quite widely in appearance. The difference in gross morphology between *C. delicatulum* and *C. solidaginis* is shown by the following table:

TABLE OF COMPARISON

Coleosporium delicatulum	*Coleosporium solidaginis*
Pycnia solitary or few, in one or two more or less extended rows, orange-chrome to English-red when fresh, on conspicuous, brightly-reddened spots.	*Pycnia* solitary or few, aggregated in one or two short rows, grenadine-red to mahogany-red when fresh, on inconspicuous, slightly-reddened spots.
Aecia inconspicuous, solitary or few, in one or two more or less extended rows.	*Aecia* conspicuous, solitary or few, aggregated in one to three short rows.
Peridia rupturing on the sides with recurved lacerate edges.	*Peridia* rupturing at the apex with irregular edges.

Coleosporium delicatulum, according to our records, has been collected in the United States as follows:

O and I on *Pinus:*

P. caribaea: Florida and Louisiana.

P. echinata: Maryland, Pennsylvania and South Carolina.

P. mayriana: District of Columbia.

P. nigra poiretiana Schneid: Pennsylvania.

P. palustris: Florida, Georgia, Mississippi and South Carolina.

P. resinosa: Vermont.

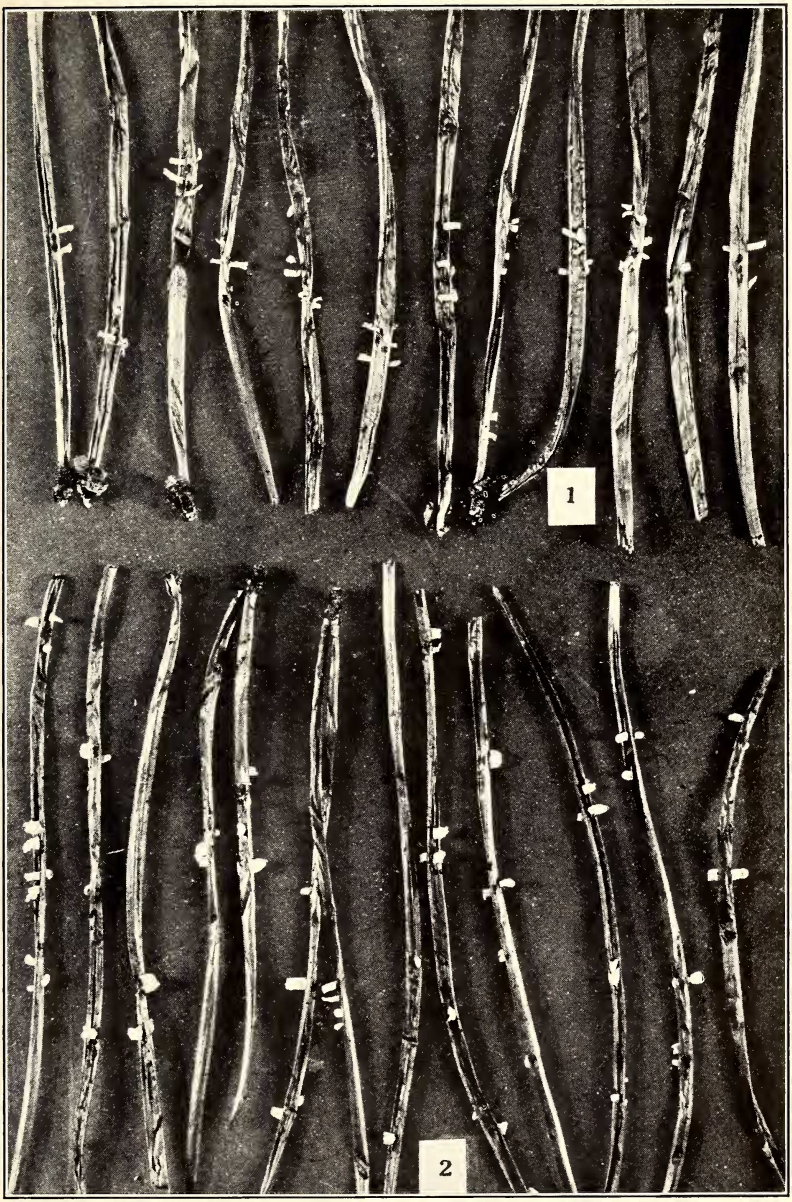
P. rigida: Connecticut, District of Columbia, Maryland, Massachusetts, New Jersey, New York, North Carolina and Pennsylvania.

P. serotina: Florida, Georgia, New Jersey and South Carolina.

P. taeda: Florida, North Carolina, South Carolina, Virginia and Texas.

II and III on *Euthamia:*

E. caroliniana: Florida and New Jersey.



SPECIES OF COLEOSPORIUM